# TWENTY-FIRST ANNUAL REPORT
N.C. State University
Cooperative Tree Improvement
and Hardwood Research Programs

School of Forest Resources
North Carolina State University
Raleigh

May, 1977

## Erratum Sheet

In Table 24, page 39, of the Twenty-First Annual Report, the units for Modulus of Elasticity should be expressed as 1000 psi.

TWENTY-FIRST ANNUAL REPORT
N. C. State University
Cooperative Tree Improvement
and Hardwood Research Programs

TABLE OF CONTENTS

TWENTY-FIRST ANNUAL REPORT

LIST OF TABLES
Cooperative Tree Improvement Program

List of Tables (cont.)

List of Tables (cont.)

TWENTY-FIRST ANNUAL REPORT
N. C. State University
Cooperative Tree Improvement
and Hardwood Research Programs

May, 1977

## REORGANIZATION

This will be the last combined annual report for the Pine and Hardwood Programs. On January 1, 1977 a series of changes were set in motion to separate the Pine and Hardwood Cooperatives. The separation will be completed by July 1, 1977, when the new fiscal year starts.

The following personnel shifts accompanied the reorganization:

1. Bill Johnson is Administrator in charge of the Pine, Fertilizer, Hardwood, and Equipment Cooperatives in the Department of Forestry.
2. Bob Kellison is Director of the Hardwood Research Cooperative; he is also Director of the Fertilizer Cooperative.
3. Bob Weir is Director of the Pine Tree Improvement Cooperative, while J. B. Jett is Associate Director.
4. Bruce Zobel has stepped down as Director of the combined Pine and Hardwood Cooperatives and is working primarily with the Pine Program as well as taking on a heavier teaching load. In addition he has more time for overseas travel, working with companies and foreign governments. Early in 1979 Bruce will take full 30-year retirement; after that he will continue half-time with the University and the other half-time will consult as opportunities arise.

The reorganization comes at an ideal time. In the Twentieth Annual Report there was a section, "Future Direction of the Cooperatives," which emphasized the need for assessing and redirecting activities of the Cooperatives. Much of the reassessment has been done in conjunction with the reorganization and the adjusted programs of the Cooperatives will be expedited under the new organization. All matters relating to reorganization have not as yet been resolved but it generally has progressed rapidly and smoothly. All persons involved feel that this reorganization and separation will result in more efficient, more productive cooperatives.

## THE COOPERATIVE PINE TREE IMPROVEMENT PROGRAM

Work related to pines continues at an increasing tempo. The need to make their land more productive has been generally recognized by the forest industries and increased effort has been expended in this direction even though timber supplies have generally been adequate during the past 12 months. Forest management in general, and forest research in particular, is now viewed much more favorably by company administrators than in the past. Support for the general area of forest management has been the best we have observed in the past 25 years.

Most of the goals for intensifying and speeding up the Tree Improvement Cooperative, as outlined in last year's annual report, have been partially or completely achieved. The push for plantation selections has produced generally good results, although several members have not kept up. A major benefit was winning the "battle" to label Furadan for control of cone and seed insects in seed orchards, the result of a Southwide effort. Second-generation and specialty orchards are being established on a large and greatly intensified scale. Best of all, "payoff day" is closer; we expect enough seed from seed orchards in fall 1977 to plant all of the 440,000 acres (334,000,000 trees) of the total planting needs of Cooperative members from seed orchard seed. This goal of full production has been achieved several years earlier than our most optimistic predictions. Now, with seed needs nearly filled, greatly increased activities can be undertaken to further upgrade the genetic quality of the seed from the orchards.

Our older seed orchards are producing well; one produced over 200 bushels of cones per acre in 1976. Shown is the 18-year-old grafted orchard of Union Camp in South Carolina.

No matter how it is viewed, the Pine Program is "jumping" and is ahead of our most optimistic earlier predictions.

## Cone and Seed Production

### Seed Orchards

Seed orchard development must proceed in steps, each toward greater genetic gain. First-generation orchards were rapidly established on a large scale with initially untested clones, with the objective of roguing out the poor genetic parents following testing. It is these first-generation orchards, now rather completely tested, that are producing the bulk of the large seed crops now being harvested; in the older orchards, one or more roguings have been done based on genetic information from progeny tests and orchard performance of the graft and its seed production capacity. No more orchards of this type, which produce a gain of 10 to 20% in volume and an equal gain in quality, will be established. Rather, new orchards will be from the second phase, which uses the best general combiner clones from the original orchards. Over 500 acres of such improved first-generation orchards, popularly referred to as 1.5-generation orchards, have been established. These orchards are needed for immediate seed production on a large scale. Along with them, the third phase, second-generation orchards, are literally "exploding" in rate of establishment. We have been advising slow development of the second-generation orchards until enough outstanding parents were available to give a suitable genetic base and to supply the needed cuttings. This time has arrived for many cooperators; and the second-generation parents, which are the best trees of the best families in the progeny tests, are outstanding and sufficiently numerous in most areas to allow orchard establishment and avoid related matings. All orchard expansion in the future will be advanced-generation orchards.

As the need arises, specialty orchards are developed. These have expanded more rapidly than expected because of the need to develop trees suitable for forest production outside their natural range. We have specialty orchards for disease resistance, wet and dry sites, and special wood properties; probably others will become important in the future.

Table 1. Coniferous seed orchard acreage in the N. C. State Cooperatives as of June 1, 1977; over 180 separate orchards are established.

| Species and Source | First-Gen. | 1.5-Gen. | Second-Gen. | Disease-Resistant | Other Specialty | Total |
|---|---|---|---|---|---|---|
| Vegetative Orchards | | | | | | |
| Coastal Loblolly | 1171 | 343 | 258 | 88 | 24 | 1884 |
| Piedmont and Mountain Loblolly | 677 | 232 | 74 | 36 | 7 | 1026 |
| Slash Pine | 564 | 50 | 9 | 29 | - | 652 |
| Longleaf Pine | 80 | - | - | - | - | 80 |
| Virginia Pine | 97 | - | - | - | - | 97 |
| White Pine | 62 | - | - | - | - | 62 |
| Sand Pine | 37 | - | - | - | - | 37 |
| Pond Pine | 32 | - | - | - | - | 32 |
| Shortleaf Pine | 23 | - | - | - | - | 23 |
| Pitch Pine | 4 | - | - | - | - | 4 |
| Spruce Pine | 3 | - | - | - | - | 3 |
| Seedling Orchards | | | | | | |
| Fraser Fir | 4 | - | - | - | - | 4 |
| Virginia Pine | 12 | - | - | - | - | 12 |
| Total | 2766 | 625 | 341 | 153 | 31 | 3916 |

Orchard development goes on rapidly, with over 180 orchards established with 3916 acres (Table 1, above); we are trying to locate them in "sexy" areas already proven for seed production. For second-generation and specialty orchards, the trend is to develop large, efficient orchard complexes in areas where pests and destructive agencies are minimal and seed production is heavy. Each orchard is buffered by having all clones established in a separate clone bank, to preserve the genotypes in case of a major disaster. We have never lost a clone completely from an orchard but we came very close when the tornado hit Kimberly-Clark's orchard several years ago. One clone had all but one large branch of one graft of one of their best clones destroyed (the parent tree was dead), and several other clones were dangerously reduced. All members of the Cooperative have now established clone banks.

Cone and Seed Yields

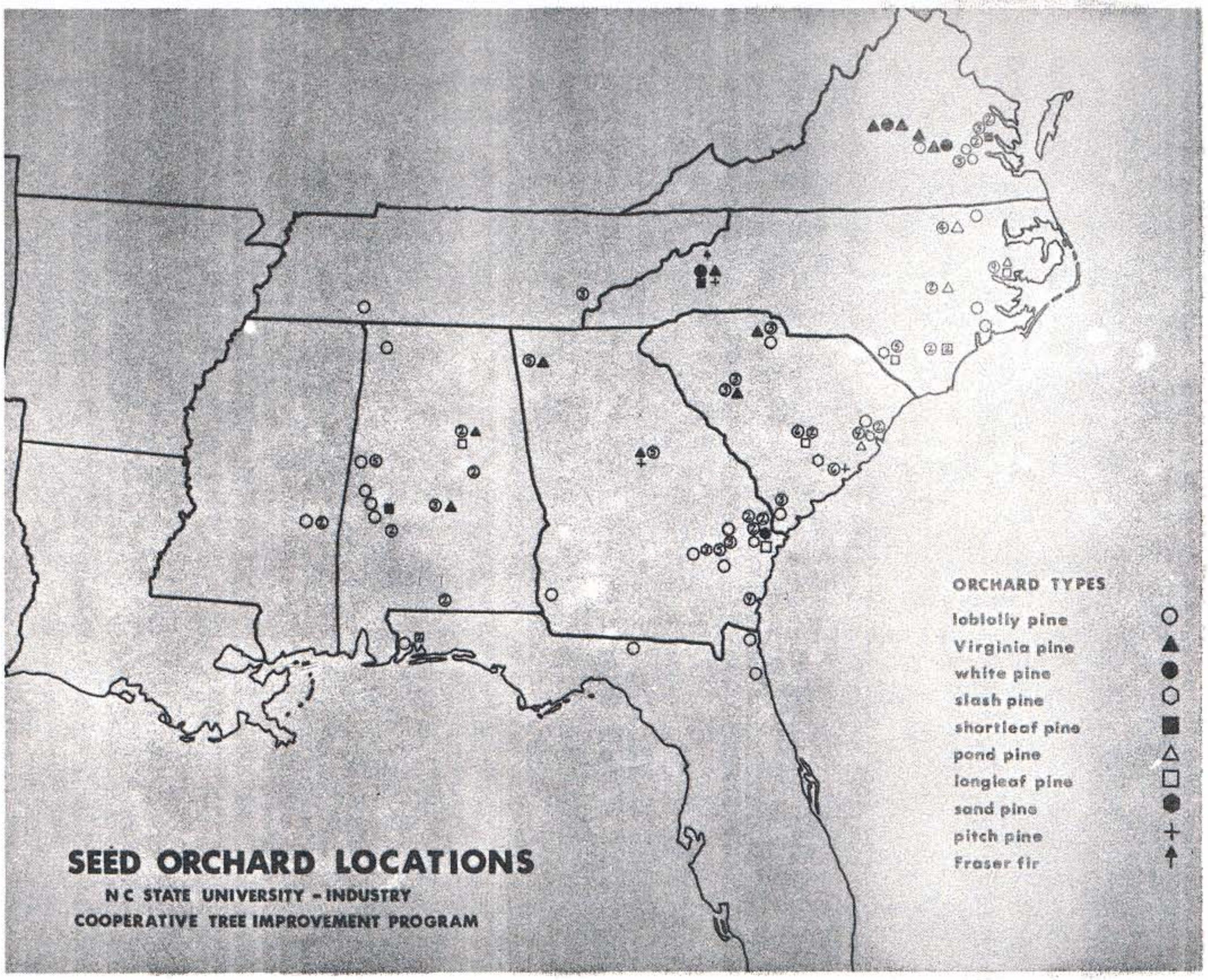
Cold weather, along with insects, periodically wreaks havoc with cone and seed yields. Each year in the annual report we show cone and seed yields since 1969 (Table 2); the small crops in 1972 and 1974 were caused by freezing weather, springs of 1971 and 1973. Similarly this year (1976) yields were drastically cut by cold in the orchards located in the Piedmont and Upper Coastal Plain. However, all but five or six orchards escaped freezes in spring 1976; and along with the good flower crop, we are expecting an all-time record collection in fall 1977, despite the past very cold winter and numerous ice and snow storms.

Table 2. Cone and seed yields within the Cooperative over the past seven years 1/

| | Loblolly | | Slash | |
|---|---|---|---|---|
| Year | Bushels of Cones | Lbs. Seed/ Bushel | Bushels of Cones | Lbs. Seed/ Bushel |
| 1969 | 1769 | 1.10 | 317 | 0.42 |
| 1970 | 5146 | 1.36 | 1744 | 0.88 |
| 1971 | 6478 | 1.14 | 3795 | 0.80 |
| 1972 | 6807 | 0.98 | 1684 | 0.60 |
| 1973 | 11853 | 1.09 | 2779 | 0.58 |
| 1974 | 8816 | 0.99 | 4088 | 0.74 |
| 1975 | 16348 | 1.31 | 5516 | 0.93 |
| 1976 | 14656 | 1.21 | 5233 | 0.79 |

1/ Loblolly flower crops were badly damaged by freezing weather in 1971 and 1973.

A comparison of the good crop in 1975 and this year's crop is shown in Table 3. Although predictions are risky, we expect at least 50% more seed in the 1977 collections. Part of this increase is due to good weather and part is due to better insect control with Furadan and Guthion. Yields per bushel tell




Seed orchards continue to expand. General locations of a number are shown on this map; there are now over 180 separate seed orchards within the Cooperative. Numbers in circles indicate the number of different orchards at a location if more than one.

the happy story. In 1977 we will obtain more seed from orchards than the total seed needs of the Cooperative.

Table 3. Comparison of the cone and seed yields for the good year 1975 and the fair year 1976 1/

| | Bushels of Cones | | Pounds of Seed | | Pounds of Seed/ Bushel of Cones | |
|---|---|---|---|---|---|---|
| | 1975 | 1976 | 1975 | 1976 | 1975 | 1976 |
| Loblolly Pine-- Coastal Source | 9284 | 8412 | 12384 | 10892 | 1.33 | 1.29 |
| Loblolly Pine-- Piedmont and Mountain Source | 7064 | 6244 | 9032 | 6859 | 1.28 | 1.10 |
| Slash Pine | 5516 | 5233 | 5146 | 4121 | 0.93 | 0.79 |
| Virginia Pine | 324 | 312 | 314 | 280 | 0.97 | 0.89 |
| White Pine | 72 | 85 | 26 | 11 | 0.36 | 0.13 |
| Pond Pine | 23 | 62 | 21 | 9 | 0.92 | 0.14 |
| Total | 22,369 | 20,348 | 26,981 | 22,172 | | |

1/ There should be an automatic increase in cones each year because of the new seed orchard acreage coming into production.

Now that members of the Cooperative are approaching full seed needs, we are recommending that an organization have at least three years' seed in storage before considering selling seed or reducing orchard acreage. Seed from rogued orchards should always be favored over nonrogued ones and seeds from 1.5-generation orchards over regular first-generation orchards.

The question has been raised several times by members of the Cooperative about prices that should be paid (or charged) for seed orchard seed. The answer now has to be, "We don't know because there is so little seed available that a market price cannot be established." Value will vary greatly with orchard, source, location and need. As a help to assess the value of seed from the extra wood produced from orchard seed, Table 4 is a reproduction of Table 22, Page 51 of the Eighteenth Annual Report. Each organization can determine its own seed values by including the assumptions it feels are most realistic.

Table 4. Present value of additional wood obtained from one pound of seed orchard seed for several stumpage values, two growth rates, and two combinations of nursery production, genetic gain, and plantation stocking

Case 1

1. One pound of seed produces 9,000 plantable seedlings
2. 500 seedlings are planted per acre (1 lb. of seed plants 18 acres).
3. Rotation age = 25 years.
4. Genetic gain = 15%.
5. Interest rate = 8%.

| Stumpage Value $/cord at time of harvest | Base Growth (cords/acre/year) | |
|---|---|---|
| | 1.5 | 2.0 |
| 6 | $89 | $118 |
| 10 | 148 | 197 |
| 12 | 177 | 236 |
| 15 | 221 | 296 |
| 18 | 266 | 355 |
| 24 | 354 | 473 |
| 30 | 443 | 591 |
| 40 | 591 | 788 |

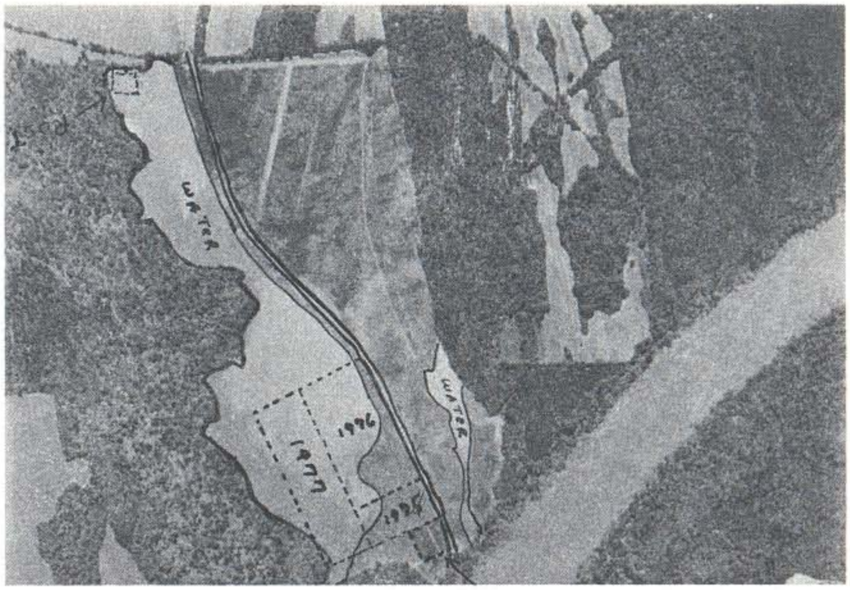
Case 2

1. One pound of seed produces 7,000 plantable seedlings.
2. 800 seedlings are planted per acre (1 lb. of seed plants 8.8 acres).
3. Rotation age = 25 years.
4. Genetic gain = 10%.
5. Interest rate = 8%.

| Stumpage Value $/cord at time of harvest | Base Growth (cords/acre/year) | |
|---|---|---|
| | 1.5 | 2.0 |
| 6 | $29 | $38 |
| 10 | 48 | 64 |
| 12 | 57 | 77 |
| 15 | 72 | 96 |
| 18 | 86 | 115 |
| 24 | 115 | 153 |
| 30 | 144 | 192 |
| 40 | 192 | 255 |

## Cone and Seed Losses

At last there is hope of controlling both seed and cone insects in seed orchards relatively simply because of the labeling of Furadan by EPA for that purpose. The label requires that the systemic be incorporated into the soil so that bird kill will be eliminated. Although Furadan is very safe dermally, it is toxic when taken internally and is very fatal to birds when the sand grains, coated with Furadan, are ingested. Current studies indicate that 99.9% of the granules of Furadan were incorporated into the soil in one test but the few granules left were found by birds. An improvement on the machine now makes it appear that 100% incorporation is possible.




Above: Tree Improvement is filled with surprises; an example is the new seed orchard of MacMillan Bloedel in Alabama. This beautiful site has not been flooded "within memory"--yet just after the grafting in 1976 it flooded twice, covering the area shown on the map. Damage was minimal as the plastic bags over the new grafts, filled with air, prevented extensive silting and molding.

Expansions of seed orchards are primarily as 1.5-generation orchards. This young Piedmont orchard of Champion International is a beauty, now coming into flowering; it represents many of the more recently established orchards.

Getting Furadan labeled was no easy task and took the joint efforts of a number of groups working together to generate the data necessary to allow labeling. There is not room to summarize even a part of the supporting studies here, but results obtained by Union Camp in northern North Carolina on loblolly pine will be indicative (Table 5).

Table 5. Tests of Furadan and Guthion on the loblolly pine seed orchard of Union Camp in northern North Carolina. Results are for protection in the second year of development only.

| Treatment | Sound Seed % | Germination % | Dead Cones by Coneworm % | Conelets Surviving May-August % | Sound Seed per Cone (number) |
|---|---|---|---|---|---|
| Furadan | 86 | 97 | 12 | 95 | 72 |
| Guthion | 79 | 99 | 17 | 89 | 78 |
| Control | 74 | 100 | 20 | 92 | 59 |

Marvin Zoerb and Lloyd Bass summarized the study:

1. Assessment of the relative effectiveness of the two treatments needs to be postponed until one complete cycle (two years) of flower and cone protection is evaluated.
2. During the second year of development, Furadan gave good protection against coneworms while control of seed bugs was good for both Guthion and Furadan, resulting in a reduction of empty seed.
3. Application of Furadan should be made a month earlier than the April 8 application in the test.

Furadan has a rather high cost per pound, and questions have been raised as to the economics of Furadan application and when it should be used. In April, 1976 an economic analysis by Ed Sossaman was sent to members of the Cooperative. He summarized by stating that all it took to break even was enough cones to equal the tree DBH, if 8 oz. Furadan/inch of DBH is used. Table 6 indicates gains and

A major problem in the use of the newly labeled Furadan for the control of seed and cone insects is to get it incorporated into the soil. Machines such as the one shown appear to solve the problem, making possible heavier seed yields from seed orchards.

Moral: Keep fire out of seed orchard. Only a very light fire burned this mowed seed orchard but most grafts were killed. Even though green needles were still present on the graft being examined, the cambium at the base of the tree was completely dead.

the economics of the use of Furadan; data are based on DeBarr's (USFS) analysis from six southern orchards.

Table 6. Returns from the use of Furadan, based upon the assumptions listed

| Orchard Production (bu./acre) | Lbs. seed without control/ acre | Gain due to 2nd-yr. control of Dioryctria (lbs.) | Gain due to 2nd-yr. control of seed bugs (lbs.) | Total gain sound seed/acre (lbs.) | Present value total gain/ acre (after tax) | R.O.I. (after tax) |
|---|---|---|---|---|---|---|
| 20 | 10.71 | .79 | 11.50 | 12.29 | 1536 | 18% |
| 30 | 16.07 | 1.18 | 17.25 | 18.43 | 2303 | 20% |
| 40 | 21.43 | 1.57 | 23.00 | 24.57 | 3071 | 22% |
| 60 | 32.14 | 2.36 | 34.50 | 36.86 | 4607 | 24% |

Assumptions:

1. Average number of sound seed/cone without control = 30.
2. Second-year control of seed bugs increases sound seed/cone by 100%.
3. Second-year control of Dioryctria increases cones/acre by 7.35%.
4. 1 lb. seed = 14,000 seed.
5. 1 lb. seed worth $125 (after tax).
6. Cost of application = $134/ac. (after tax).
7. There are 250 cones/bu.
8. Interest rate = 8%.

In a determination about the causes of seed losses, Capony, et al.[1/] report on a detailed study made by the Virginia Division of Forestry. They reported losses both as conelets and cones and as seed in mature cones (Table 7).

Table 7. Impact of insects on cone and seed production of five clones from the loblolly pine seed orchard of the Virginia Division of Forestry, from unsprayed trees

| Fate of Cones and Conelets | | Seed Fate in Harvested Cones | |
|---|---|---|---|
| 1. Harvested cones | 57.8% | 1. Filled seed | 46.2% |
| 2. Coneworm infested, cones and conelets | 17.7% | 2. Hollow seed from seed bugs | 0.1% |
| 3. Aborted conelets and cones by seed bugs | 14.2% | 3. Aborted ovules by seed bugs, first year | 22.3% |
| 4. Physiologically aborted cones and conelets | 6.5% | 4. Hollow seed | 10.4% |
| 5. Unknown | 3.8% | 5. Physiologically aborted ovules | 21.0% |

[1/] Capony, J. A., R. G. Wasser, and T. C. Tigner. 1976. Evaluation of seed losses by mortality factors of the 1974-75 loblolly pine seed crop. New Kent Forestry Center, Providence Forge, Va. Mimeo.

Their conclusions were that losses to insects were much greater the first year than the second (28% vs. 9%), indicating control measures should be primarily toward protecting first-year crops. They found that of the potential of 165 seed per cone, only 44 seed were harvested.

During the past several years, seed yield losses caused by insects have been much recognized and a tendency has developed to ascribe most losses to insects. Sometimes they are not the sole culprit, particularly in "cone caging" tests in which the cones were bagged with wire or plastic mesh. When yearling cones were caged for the second year of development, results were sometimes but not always good. When caged for two years, results were almost always bad, with the cones dying, not growing well, or producing few sound seed. It has been reported that for some types of mesh cover, insects lay their eggs on the mesh; the young larvae crawl through the mesh, resulting in more severe insect damage inside the cage than from noncaged cones. In a caging test made by Union Camp in Virginia on loblolly pine, results for 17 clones illustrate the larger number of empty (or pop) seeds obtained from caged versus noncaged cones.

| | Caged | Uncaged |
|---|---|---|
| Total seed/cone | 64.8 | 55.6 |
| Empty seed/cone | 41.4 | 26.6 |
| Sound seed/cone | 23.4 | 29.0 |

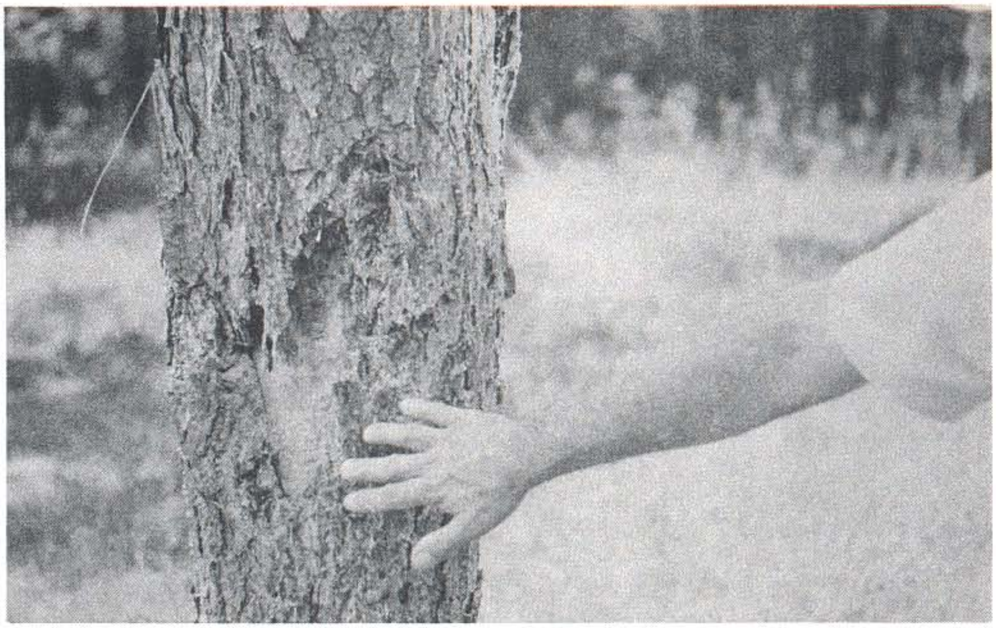
## Second-Generation Orchards

Progress with second-generation selections has been good but there are some frustrations. A special one is the disproportionately high number of selections coming from crosses of certain parents because they are good general combiners. This results in many related selections, only a few of which can be used in a single second-generation seed orchard. A good example of this is the recent grading of second-generation selections by Westvaco; of the 25 trees graded and accepted, 13 had 11-23 as one parent while 10 had 7-56 as one parent. This is frustrating for getting a broad base of second-generation selections but indicates the quality of trees to be obtained from an orchard when good general combiners are left, the poor parents rogued.

In an attempt to explain this to the Advisory Committee, Bob Weir prepared a schematic diagram showing what happens to the average company which uses five testers and twenty clones (see Table 8). This was developed based on experience with a number of companies. About 40% of the crosses made to test a seed orchard will be represented by second-generation selections but with a major concentration involving the good general combiners and testers.

Table 8. Schematic diagram of second-generation selections from an "average" company in the Cooperative, using five testers

| | Testers | | | | | |
|---|---|---|---|---|---|---|
| Clones | A | B | C | D | E | Total |
| 1 | 6 | 3 | 4 | 2 | | 15 |
| 2 | 4 | 6 | 1 | | | 11 |
| 3 | 3 | 2 | | 1 | 3 | 9 |
| 4 | 4 | 4 | 3 | | | 11 |
| 5 | 5 | | | | | 5 |
| 6 | 2 | 2 | 5 | | | 9 |
| 7 | | 3 | | | 2 | 5 |
| 8 | | | 1 | | | 1 |
| 9 | 1 | | 2 | 2 | | 5 |
| 10 | | 3 | | | | 3 |
| 11 | 1 | | | | | 1 |
| 12 | 2 | 1 | 2 | 3 | 1 | 9 |
| 13 | 2 | | | | | 2 |
| 14 | | | | | | 0 |
| 15 | 1 | | | 2 | | 3 |
| 16 | | | 1 | | | 1 |
| 17 | 2 | | | | | 2 |
| 18 | | 2 | | | | 2 |
| 19 | 1 | | | | | 1 |
| 20 | | | | | 1 | 1 |
| Total | 34 | 26 | 19 | 10 | 7 | 96 |



A major problem in some of the older slash pine orchards is damage by the tree shaker. Much damage has been done by careless use of the shaker; in addition to the physical damage, pitch canker often gets into the wounds.

Grafting one pine species on another is sometimes beneficial. Shown is a sand pine graft on a slash pine rootstock in Union Camp's orchard; these survive and grow better than when sand pine is grafted on sand pine rootstock.

Sometimes there are considerable variations from the average pattern shown in Table 8; an example is shown for the acceptable selections of Westvaco in South Carolina. Here tester differences were minimal but 7-56 was so overpowering that over half the selections had this clone as one parent (Table 9). Such an inequality makes it extremely difficult to develop second-generation seed orchards, using the very best selections while also maintaining nonrelatedness. Of the numerous selections made, only a few can be used.

Table 9. Second-generation selections from Westvaco's Coastal South Carolina seed orchard

| | 11-23 | 11-20 | 11-2 | 11-10 | 11-16 | Total |
|---|---|---|---|---|---|---|
| 7-56 | 5 | 5 | 5 | 2 | 3 | 20 |
| 7-2 | 1 | 3 | | 1 | | 5 |
| 11-9 | 1 | | 1 | | 2 | 4 |
| 11-3 | | | | 2 | | 2 |
| 11-19 | 1 | | | | | 1 |
| 7-52 | 1 | | | | | 1 |
| 11-18 | | | 1 | | | 1 |
| 11-51 | | | | 1 | | 1 |
| 11-41 | | | | 1 | | 1 |
| 11-8 | | | | | 1 | 1 |
| Total | 9 | 8 | 7 | 7 | 6 | 37 |

## Trees for Problem or Different Sites

The development of trees for problem sites is a major activity of the cooperators. One most perplexing problem concerns what to grow on the droughty, deep-sand sites in areas of high fusiform rust incidence. Species that have been tried generally will not grow well or have been severely damaged by rust.

St. Regis initiated a study to help solve this problem. Plantations were established in three counties in Georgia where high rust rates occur. Results of their study after five growing seasons are shown in Table 10. Note the especially low infection rate for the Texas source with its quite acceptable growth rate for severe sites. The high fusiform infection and slow growth of slash pine was a surprise in this area where slash pine has been the preferred species. Differences in growth rate and infection percent in the four different test sites are most interesting.

Table 10. Growth and fusiform rust infection of three loblolly sources and one slash pine source after five years' growth in three counties in Georgia[1/]

| Location of Test | Slash Pine | Nursery Loblolly | East Texas Loblolly | Marion County, Florida Loblolly | Average |
|---|---|---|---|---|---|
| | Height (ft.) | | | | |
| Early County | 12.1 | 14.8 | 14.6 | 15.4 | 14.2 |
| Stewart County | 11.6 | 14.0 | 14.3 | 14.4 | 13.6 |
| Worth County | 6.6 | 8.8 | 8.7 | 9.3 | 8.4 |
| Average | 10.1 | 12.5 | 12.5 | 13.0 | |
| | DBH (in.) | | | | |
| Early County | 2.4 | 3.1 | 2.9 | 3.3 | 2.9 |
| Stewart County | 2.3 | 2.8 | 2.9 | 3.0 | 2.8 |
| Worth County | 1.3 | 1.4 | 1.4 | 1.5 | 1.4 |
| Average | 2.0 | 2.4 | 2.4 | 2.6 | |
| | Volume (cu.ft.) | | | | |
| Early County | .140 | .275 | .250 | .339 | .251 |
| Stewart County | .136 | .227 | .257 | .275 | .224 |
| Worth County | .032 | .043 | .052 | .056 | .046 |
| Average | .103 | .181 | .186 | .223 | |
| | Fusiform Rust--% Infection | | | | |
| Early County | 68 | 56 | 12 | 70 | 52 |
| Stewart County | 38 | 17 | 3 | 29 | 22 |
| Worth County | 44 | 56 | 9 | 68 | 44 |
| Average | 50 | 43 | 8 | 56 | |
| | Survival--% | | | | |
| Early County | 56 | 87 | 80 | 83 | 77 |
| Stewart County | 71 | 84 | 85 | 84 | 81 |
| Worth County | 47 | 77 | 75 | 57 | 64 |
| Average | 58 | 83 | 80 | 75 | |

In addition to trying other species or other sources, crosses between proven drought-hardy and local sources were tested on droughty sites by Westvaco Corporation (Table 11). Large differences in growth and rust infection are evident among the parents, and the performance of the crosses completely dependent on the particular parental combinations used.

Table 11. Four-year performance of local, Texas and local-x-Texas loblolly pine on a droughty, sandy site in Coastal South Carolina 1/

| Source | Average Height (ft.) | Fusiform Infection (%) 1/ |
|---|---|---|
| Local Loblolly 2/ | 13.2 | 55 |
| Texas Loblolly 2/ | 12.5 | 38 |
| Local-x-Texas Loblolly | 12.1 | 30 |

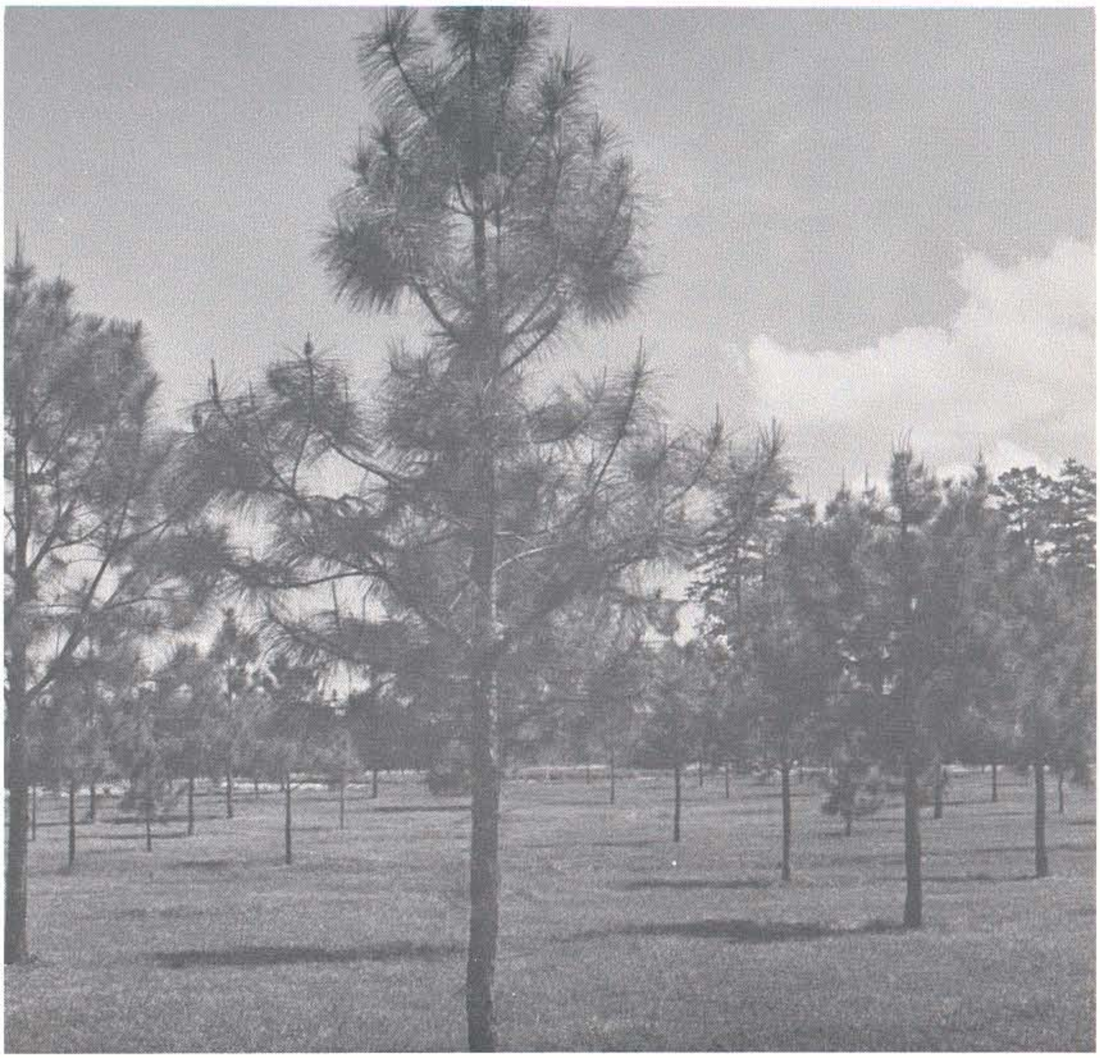
1/ Infection varied in the test from 3.9% to 85.2%.
2/ Open-pollinated seed from parents used in the crosses

Some sites become very wet following logging; an attempt has been made to develop trees suitable for these areas. One area near Franklin, Virginia had consistently poor growth following replanting. The genetically improved "deep peat" source from Westvaco, a local source, and regular loblolly were grown along with genetically improved pond pine. First-year results showed considerable superiority for the wet-site seed orchard stock; this has been reduced considerably once the trees "captured" the site following ten years in the field.

Table 12. Ten-year results of a test of special wet-site sources and pond pine on a wet mineral soil of Union Camp in Virginia (Numbers in parentheses indicate ranking.)

| | Height (ft.) | Volume (cu.ft./tree) | Crown 1/ | Straightness 1/ |
|---|---|---|---|---|
| Regular Planting Stock | 25.8 (3) | 1.322 (3) | 3.5 (4) | 3.7 (4) |
| Local Loblolly Source | 27.0 (2) | 1.331 (2) | 3.2 (1) | 3.3 (3) |
| Wet-Site Orchard Source | 27.3 (1) | 1.343 (1) | 3.2 (1) | 3.2 (2) |
| Pond Pine Orchard Source | 24.9 (4) | 1.093 (4) | 3.2 (1) | 2.9 (1) |

1/ Lower scores indicate smaller limbs and straighter boles, i. e., improved form.



Although approximately 85% of the effort is directed toward loblolly pine, minor species are also important in the Pine Cooperative. Shown is a young pond pine orchard of the North Carolina Forest Service in North Carolina, already producing abundant flowers.

The growth superiority of the wet site orchard source is not great but is consistent; tree form is much better than the usual planting stock. Pond pine had amazingly good form but poorer growth than the loblolly pine.

Of great importance to the Cooperative is to find strains and species or develop strains of trees to grow well outside the normal pine range. Results to date have been very good but there is still a long way to go. Older studies are producing results that are being applied in operational studies. Westvaco has established numerous adaptability studies; shown in Table 13 are results from 8-year-old tests of various sources of loblolly pine grown outside the species range in West Virginia.

Table 13. Eight-year performance of geographic sources of loblolly pine when grown on lands of Westvaco in West Virginia

| Loblolly Source | Percent Survival | | Height (ft.) 1/ | | Diameter (in.) 1/ | |
|---|---|---|---|---|---|---|
| | Gentry Tract | Cole Tract | Gentry Tract | Cole Tract | Gentry Tract | Cole Tract |
| Maryland | 70 | 82 | 19.0 (3) | 22.0 (3) | 4.0 (5) | 4.1 (5) |
| Tennessee | 66 | 87 | 20.2 (2) | 21.7 (4) | 4.3 (2) | 4.3 (3) |
| Alabama | 82 | 82 | 20.4 (1) | 22.5 (2) | 4.4 (1) | 4.4 (2) |
| Arkansas | 51 | 56 | 18.4 (5) | 19.7 (7) | 4.1 (4) | 3.9 (6) |
| South Carolina | 58 | 66 | 17.9 (6) | 20.7 (6) | 3.8 (6) | 3.6 (7) |
| Virginia | 27 | 24 | 18.6 (4) | 23.0 (1) | 4.2 (3) | 4.6 (1) |
| Kentucky | 56 | 67 | 17.5 (7) | 21.2 (5) | 3.7 (7) | 4.2 (4) |
| Average | 58 | 66 | 18.9 | 21.5 | 4.1 | 4.2 |
| Virginia Pine Check | - | - | 15.3 | 17.8 | 3.4 | 3.4 |

1/ Ranks indicated in parentheses

Generally the southern sources grow faster, but in this instance climate is so severe at the test site that the South Carolina source did not generally perform well. The Alabama source is the best all-around, the Tennessee being nearly as good. The very low survival of the fairly fast-growing Virginia source is a puzzle as this source usually does well in more severe sites. The source with the straightest boles and smallest limbs were from Arkansas and Maryland, with other sources having heavier limbs and more crooked boles. Form and growth were reasonably similar on the two sites, one of which was of considerably higher site quality than the other.

Care must be taken not to move trees too far from the area in which they were initially tested. Already, some general rules are available such as not moving Piedmont sources to the Coastal Plain, not moving southern sources too far north, not selecting from a wet site to plant on a dry site. The question that always arises is how far. This has become especially important as members of the Cooperative are forced to consider planting considerably out of the species range.

A good example is one study by Henry Barbour of Westvaco who tried a number of different pine seed lots from various areas. When taking survival data after one growing season, mortality varied from zero to 54%. The striking thing is the relationship of survival to geographic area of source; for example, the five Virginia sources had essentially zero mortality while the southern sources were as follows:

| | Percent Mortality |
|---|---|
| Five Virginia Sources | 0 |
| South Carolina Coastal | 14 |
| South Carolina Coastal | 37 |
| South Carolina Coastal | 7 (This family is a good general combiner and overall good performer.) |
| Georgia Coastal | 35 |
| Gulf Hammock, Florida | 30 |
| Marion County, Florida | 54 |
| Livingston Parish, Louisiana | 50 |

There is continuing interest in the Livingston Parish, Louisiana source of loblolly pine because it is a good grower and has been remarkably disease resistant, especially in tests at the Asheville Test Center. Nearly 70 different field tests have been established and the growth and disease picture of this seed source will soon be clear.

One small study was assessed by Westvaco in South Carolina at two years of age. It showed the Livingston Parish to be slow-growing, equal in rust to the seed orchard crosses exclusive of those involving 11-23 and about equal to the commercial checks. The Florida source was rust-susceptible, having the same infection as crosses with super-susceptible 11-23 (Table 14).

Table 14. Two-year growth, survival and fusiform infection Livingston Parish, with other lots 1/

| | Height (ft.) | Survival (%) | Infection (%) |
|---|---|---|---|
| Crosses from the Coastal Plain Seed Orchard (10 lots) | 6.7 | 90 | (23 & 7) 2/ |
| Livingston Parish (5 lots) | 6.2 | 95 | 7 |
| Florida (Gulf Hammock) (1 lot) | 7.6 | 90 | 22 |
| Commercial Check (1 lot) | 6.3 | 93 | 8 |

1/ From a small test by Westvaco Corporation in South Carolina

2/ Crosses with susceptible parent 11-23 (except the resistant 7-56 crossed to 11-23) averaged 23% infection, all other crosses including 7-56 x 11-23 averaged only 7%. Cross 11-23 x 11-23 had 31% infection.

## Broadening the Genetic Base

One of the major objectives of the Cooperative is to keep the genetic base broad to allow breeding for a number of generations without running into problems of relatedness. This requires a major effort which is already underway with several approaches being used.

The effort requiring the greatest input from members of the Cooperative is to select 100 more trees from plantations (wild stands if plantations aren't available) for each major seed orchard. This effort was to be over a four-year period, and two years are already gone. Except for a couple of members, the program is right on schedule and several members have nearly completed the job.

Not all forestry deals with trees. Jim Hill of Hiwassee has a knack for finding historically interesting things such as this very old graveyard in the center of their second-generation seed orchard.

The urgency is necessary so these trees can be established in a breeding clone bank and bred for incorporation into the third-generation production program. It is essential to obtain selections from plantations established from wild seed; because of the presence of strong general combiners, plantations from seed orchards cannot be used. Many of the older plantations are now being harvested and we need to select the best trees before they are all gone.

Progress is shown in Table 15; these trees, added to the total wild selections of 2,639 trees for all species already in the program, give a considerably expanded genetic base for the breeding program. The plantation selections are immediately being established in clone banks and will be crossed and their progeny tested as soon as they begin to flower three to four years after grafting.

Table 15. Progress in selecting pine trees from plantations

| Species and Source | Plantation Selections to April 1, 1976 | Selections Added in the Last Year | Plantation Selections to April 1, 1977 |
|---|---|---|---|
| Loblolly-- | | | |
| Coastal | 223 | 176 | 399 |
| Piedmont and Mountain | 88 | 237 | 325 |
| Slash | 55 | 41 | 96 |
| Total | 366 | 454 | 820 |

Another activity to broaden the base is to make wide crosses between trees that could never cross naturally. An original wide crossing was initiated by Ron Woessner in 1968, in which pollen from outstanding trees from ten differing geographic sources was used on the best females in a Piedmont and a Coastal Plain orchard in North Carolina. Plantations of this material were outplanted on ten greatly differing sites. These plantings have supplied a large number of outstanding second-generation selections that have already broadened the genetic base of established second-generation seed orchards. Crossing among the best general combiners from different seed orchards is now well started, with 420 done, and wide crossing among second-generation selections will be initiated in the future.

Because of the huge size of the Cooperative Program with its many selections, there is currently no major problem with keeping the genetic base suitably broad, especially for adaptability and pest resistance. However, as we look forward to the third and fourth generations, problems could be envisioned. However, we can even now state categorically that no major problems will result because of the fine way the members of the Cooperative have supported activities needed to keep a broad base. If studies should show that mild related matings can be tolerated, then we are in an excellent position indeed. Long-term future planning and action of the type to keep the genetic base broad is necessary to keep the program viable and vital.

## Progeny Test Results

Seed orchard parents are tested in main and supplemental tests, with most supplemental plantations established on sites that differ from the main tests. One of the fastest-growing progeny tests, planted in 1967, is on a super-site on lands of Westvaco in coastal South Carolina. The test is very small, so firm conclusions cannot be made, but the overall outstanding growth rate of 45.7 feet and 7.2 inches DBH in ten years is outstanding. Also, family variations of 10 to 84% in fusiform rust infection or 6.6 inches DBH to 8.3 inches show how different crosses from a seed orchard can be (Table 16).

As operational plantations and progeny tests from the seed orchards get older, the improvement in bole straightness and crown quality over normal loblolly pine becomes more outstanding. But growth rate has also been outstanding; this is shown by the oldest control-pollinated test in the Cooperative by Westvaco in coastal South Carolina. This was an unusual test in that the same mother-tree was pollinated by pollen from ten other select trees. Unfortunately no commercial check was included but the growth rate of the crosses speaks for itself.

Table 16. Ten-year results of a small supplemental loblolly pine progeny test on an excellent site of Westvaco in coastal South Carolina

| Cross | Height (ft.) | DBH (in.) | Fusiform Infection (%) |
|---|---|---|---|
| 11-16 x 11-2 | 48.8 | 8.3 | 50 |
| 7-56 x 11-20 | 47.8 | 6.9 | 10 |
| 11-23 x 11-20 | 47.8 | 7.7 | 35 |
| 7-56 x 11-23 | 47.6 | 7.5 | 22 |
| 11-23 x 11-16 | 46.3 | 7.0 | 84 |
| 7-2 x 11-23 | 43.8 | 7.3 | 66 |
| 7-56 x 11-16 | 43.4 | 6.6 | 22 |
| Seed Production Area | 43.1 | 6.9 | 52 |
| Commercial Check | 43.0 | 6.8 | 40 |
| Test Average | 45.7 | 7.2 | 42.3 |

Fifteen-year growth is shown in Table 17. Since the same mother-tree is common to all tests, differences among the crosses are primarily due to differences from the male parent. Note that there is over 90% difference in volume among the crosses. Although it can't be seen from the data, this once-thinned planting is one of the most beautiful loblolly pine stands I have ever seen.

Table 17. Growth rate of control-pollinated loblolly pine, 15 years of age, on lands of Westvaco Corporation in the Coastal Plain of South Carolina

| Cross | Height (ft.) | DBH (in.) | Volume (cu.ft.) |
|---|---|---|---|
| 11-2 x 11-18 | 63.6 | 10.1 | 13.0 |
| 11-2 x 11-41 | 62.2 | 9.6 | 11.4 |
| 11-2 x 7-2 | 61.8 | 10.6 | 13.9 |
| 11-2 x 7-34 | 61.4 | 9.5 | 11.2 |
| 11-2 x 11-9 | 60.5 | 9.5 | 11.0 |
| 11-2 x 11-20 | 60.5 | 8.6 | 9.6 |
| 11-2 x 7-56 | 59.3 | 8.5 | 8.9 |
| 11-2 x 11-19 | 59.2 | 9.2 | 10.6 |
| 11-2 x 11-16 | 55.5 | 9.1 | 9.0 |
| 11-2 x 11-14 | 55.0 | 7.8 | 7.0 |
| Test Average | 59.9 | 9.2 | 10.6 |

A major effort within the Cooperative has been to obtain select trees from plantations. Success has been good, especially in areas where there are numerous good plantations such as this one of Union Camp in Georgia. Barry Malac is leaning against a candidate for grading.

Differences as large as those shown are remarkable with a common mother. Some were undoubtedly due to varied fusiform rust infection. Wood weight differences based on 8-year measurements were also great, varying from 26.2 lbs./cu.ft. (11-2 x 7-2) to 21.9 lbs./cu.ft. (11-2 x 11-9).

Because of increased usage of fertilizers there is continued interest as to whether some parents respond better to fertilizers than do others. A summary paper was prepared for loblolly and slash pine[1/] summarizing results to date. Those for 8-year-old loblolly pine are as follows:

1. All families responded to fertilization where there was a significant overall fertilizer effect.
2. Usually the faster-growing unfertilized family was the faster-growing following fertilization; although occasional exceptions occurred, F-tests did not show any statistically significant genotype-x-fertilizer interaction.
3. The faster-growing families generally responded less to fertilization than did the slower-growing ones.

Results can be illustrated by a small study of 8-year-old loblolly pine by Hiwassee in the Cumberland Plateau of Tennessee (Table 18).

Table 18. Eight-year height growth of loblolly pine crosses of Hiwassee, with and without fertilization 1/

| | Fertilized[2/] | | Nonfertilized | |
|---|---|---|---|---|
| | Height (ft.) | Rank | Height (ft.) | Rank |
| 1-68 x 1-14 | 22.8 | 1 | 21.6 | 1 |
| 1-60 x 1-66 | 21.4 | 2 & 3 | 20.1 | 3 |
| 12-7 x 1-10 | 21.4 | 2 & 3 | 18.6 | 5 |
| 1-14 x 1-10 | 21.1 | 4 | 20.7 | 2 |
| 12-13 x 1-10 | 20.6 | 5 | 19.4 | 4 |
| Mountain--Comm. Ck. | 19.4 | 6 | 18.2 | 6 |
| 12-7 x 1-14 | 19.1 | 7 & 8 | 16.6 | 8 |
| Piedmont--Comm. Ck. | 19.1 | 7 & 8 | 17.1 | 7 |
| Average Height | 20.6 | | 19.0 | |
| Range | (19.1 - 22.8) | | (16.6 - 21.6) | |

1/ Goddard, R. E., B. J. Zobel and C. A. Hollis. 1976. Response of southern pines to varied nutrition. Physio. Gen. Conf., Edinburgh, Scotland. 25 pp.

2/ A balanced fertilizer was used.

A large 8-year test on Weyerhaeuser's lands in coastal North Carolina shows what sometimes happens with specific crosses. This planting was on a wet site, grown with minimal care and minimal site preparation. Half the test was fertilized with P and K but no nitrogen was added. Competition normally found on wet sites, such as red maple, was fierce and the trees are only now beginning to "capture" the site. Most crosses maintained their relative ranking but a few did not, as illustrated in Table 19. Note the nearly 50% improvement in height growth resulting from the fertilization and the relatively poor growth of the commercial check.

Table 19. Crosses that have interacted in height growth with fertilization compared to those that did not. Eight-year-old loblolly pine on the Coastal Plain of North Carolina, lands of Weyerhaeuser.

| | Unfertilized | | Fertilized | |
|---|---|---|---|---|
| Cross | Avg. Ht. (ft.) | Rank | Avg. Ht. (ft.) | Rank |
| No interaction: | | | | |
| 8-33 x 8-103 | 10.96 | 8 | 15.48 | 8 |
| 8-65 x 8-33 | 10.11 | 17 | 14.64 | 18 |
| 8-31 x 8-64 | 9.88 | 20 | 14.48 | 21 |
| 8-46 x 8-141 | 9.60 | 23 | 14.29 | 23 |
| Interaction: | | | | |
| 8-76 x 8-31 | 11.68 | 4 | 14.27 | 24 |
| 8-64 x 8-76 | 10.07 | 19 | 14.93 | 4 |
| 8-33 x 8-21 | 9.43 | 25 | 16.00 | 3 |
| 8-33 x 8-73 | 9.17 | 30 | 15.46 | 9 |
| Commercial Check | 9.23 | 27 | 13.83 | 27 |
| Plantation Average | 10.19 | | 14.90 | |

## Fusiform Resistance

Every year J. B. Jett develops a list of the most disease-resistant clones in the Cooperative. The list grows every year, with some clones being dropped but more being added. Currently there are 34 clones listed as excellent, 56 more as good. It is not easy for a clone to make this list because it is only rated after appearing in several tests for several years, usually on differing sites. No company has a strong lead in the relative proportion of resistant clones, although as of now Catawba, in a bad rust area, has the largest proportion of its clones in the excellent category. Champion, nearby in the South Carolina Piedmont, has a number of clones in both the excellent and the good categories.

The disease diallel tests have developed well. The initial crossing consisted of a half-diallel of 22 clones which at the time represented the most Cronartium-resistant parents available in the Cooperative. Outplanting of this material began in 1975 with two 6-rep tests planted in the Coastal Plain and two in the Piedmont in areas of high rust incidence. The current planting season will see the completion of three years of outplanting and will bring the total number of test plantings to 13.

There has been discussion regarding how often tests need to be repeated over years and sites to get good estimates of fusiform rust infection. Bob Kellison calculated this on a gross basis by cooperator; a summary of four companies is shown in Table 20.

Yearly fluctuations are evident, especially in the moderate rust area where specific location is very important. Even though the tests contained different crosses, similar testers were used, meaning that about half the parentage was common over years. In the mild rust area, disease is not a problem in any year, even though up to a fivefold fluctuation was evident from year to year. Despite local fluctuations it appears that testing in a single year in a bad rust area is sufficient, but more than one test will be needed when testing is in an intermediate rust area. Local site conditions at the test area or annual climatic fluctuations can cause very large differences in test averages for rust infection, unless it is very bad or very light.

Genetic differences are evident in the bed as shown in Kimberly-Clark's nursery. Because of differences in growth curves among families, these initial differences may or may not be maintained as the trees get older.

This is something to be proud of--the oldest control-pollinated progeny test of loblolly pine in the Cooperative. Form and growth of this 16-year-old Westvaco planting in South Carolina are superb.

Table 20. Change in average percent fusiform rust infection from year to year and test to test for several cooperators

| Cooperator | Year | | Percent Infection |
|---|---|---|---|
| Champion | 1965 | | 68 |
| (Piedmont, S. C.-- | 1966 | | 72 |
| Bad rust area) | 1967 | | 82 |
| | 1968 | | 56 |
| | 1969 | | 83 |
| | 1970 | | 82 |
| | | Average | 74 |
| Continental Can | 1966 | | 42 |
| (Piedmont, Ga.-- | 1967 | | 46 |
| quite bad area) | 1968 | | 36 |
| | 1969 | | 37 |
| | 1971 | | 69 |
| | | Average | 46 |
| Union Camp | 1965 | | 19 |
| (Coastal Plain, Ga.-- | 1966 | | 45 |
| Moderate rust area) | 1967 | | 32 |
| | 1968 | | 20 |
| | 1970 1/ | | 17 |
| | 1970 1/ | | 66 |
| | | Average | 33 |
| Weyerhaeuser | 1964 2/ | | 10 |
| (Coastal Plain, N. C.-- | 1964 2/ | | 12 |
| mild rust area) | 1965 | | 13 |
| | 1965 | | 13 |
| | 1966 | | 7 |
| | 1966 | | 7 |
| | 1967 | | 3 |
| | 1967 | | 3 |
| | 1968 | | 12 |
| | 1968 | | 16 |
| | 1969 | | 8 |
| | 1969 | | 10 |
| | 1970 | | 9 |
| | | Average | 10 |

1/ Planted at two locations; note differences in percent infection.
2/ Two tests planted yearly, one North Coastal, one South Coastal.

The primary criterion by which the success of the forest genetics program has been judged is on volume or dry wood weight gains. But this is only a part of the story! Major improvements in wood and tree quality also are obtained. The difficulty relates to the assignment of dollar values; it is easy to determine the worth of yield differences but difficult to determine the worth of quality improvement.

A major start on determining the value of quality was made several years ago by means of a very large study by International Paper Company in which (1) large-limbed, crooked trees, (2) large-limbed, straight trees, (3) small-limbed, crooked trees, and (4) small-limbed, straight trees were pulped. Results have been reported in earlier annual reports and in Tappi.

However, quality of tree as it affects pulp properties is only a part of the story. A major question is "What effect will tree quality have on solid wood products?" To obtain answers to this question, several studies are underway as to strength properties and yields of lumber or value for poles from trees of different types. A couple of these studies are nearing completion; one dealing with plywood has recently been completed.

In Virginia, Georgia-Pacific Corporation undertook a study involving 180 large loblolly pine trees approximately 40 years old. These were divided into three categories: (a) straight, small-limbed; (b) woods-run (taken as they come); (c) crooked, large-limbed. As the study developed, it became clear that category (c) should not be carried further because (1) it is a category that will normally not be separated out; (2) the 60 trees averaged 2.3" larger in diameter than the woods-run trees. Plywood yields are so closely tied to log size that it was felt this comparison would not be justified even though the quality of plies from the rough trees was somewhat lower than from the other two categories. The straight, small-limbed trees were a little larger than the run-of-the-mill group (Table 21), but overall the size comparison can be considered good for the manner in which the trees were selected. The small-limbed, straight trees thus had a little advantage because of the somewhat larger trees represented; size differences could in no way be ascribed to tree form--size differences and tree form were random.

Progeny testing is essential, as illustrated by this young test of Champion International in South Carolina. To Bill Morse's right is a progeny from mother 3-6, which throws approximately 30% roundish, branchy dwarfs. Behind Bill is a normal family just starting its fourth year's growth.

Variation among progeny from different crosses within a seed orchard can be very large, as illustrated for Georgia Kraft in Georgia. The 3-year-old family to Billy Arnold's left is nearly twice as large as the family to his right.

Table 21. Characteristics of the 120 trees used in Georgia-Pacific's plywood yield and quality study

| Tree Characteristic (Avg. of 60/category) | Straight, Small-Limbed | Woods-Run |
|---|---|---|
| Height (ft.) | 99.5 | 92.1 |
| Diameter (in.) | 15.8 | 15.1 |
| Green Weight (incl. bark) of trees used (lbs.) | 3,219 | 3,002 |
| Green weight of unused tops (lbs.) | 46 | 61 |
| Total Green Weight | 3,265 | 3,063 |
| Straightness Rating 1/ | 2.2 | 3.8 |
| Crown Rating 1/ | 2.7 | 3.8 |

1/ A straight or small-crowned tree would rate 1; a crooked or large-crowned tree would rate 5. Differences of 2.2 to 3.8 or 2.7 to 3.8 indicate that form differences in the two groups of trees were considerable.

The diameter distribution of the trees is described below:

| Diameter Class (in.) | Number of Trees in Class | |
|---|---|---|
| | Straight, Small-Limbed | Woods-Run |
| 12 | 5 | 9 |
| 14 | 19 | 19 |
| 16 | 19 | 25 |
| 18 | 12 | 6 |
| 20 | 4 | 1 |
| 22 | 1 | - |
| Total | 60 | 60 |

The major objective of the test was to determine yield differences by tree category as a percentage of green weight of wood; these differences were translated to dollar values by generalized but accurate values of products in mid-1976 (Table 22). Additionally, quality of plies obtained was determined but no dollar values were assigned to these differences. Dollar values related only to yield were assigned to the following:

1. Finished plywood
2. Finished lumber from cores of ply-log bolts and other logs not suitable for peeling.
3. Chips and miscellaneous by-products such as shavings, plywood trim, sawdust and bark
4. Unused tops. Although the percentages were small (1.4% for straight, small-limbed trees, 2.0% for woods-run trees), a realistic chip value was assigned to tops.

Table 22. Value of the products from straight, small-limbed and woods-run trees when all products are combined

| | $ Value per 1,000 Pounds of Green Weight of Trees | |
|---|---|---|
| | Straight, Small-Limbed | Woods-Run |
| Finish plywood | 19.97 | 16.21 |
| Lumber from cores and unsuitable veneer logs | 2.95 | 3.43 |
| Chips | 2.19 | 2.61 |
| Residue (shavings, sawdust, ply-trim, bark) | .18 | .20 |
| Total value/1,000 lbs. green weight of trees | 25.29 | 22.45 |

Gain in product value = 12.7%.

Table 23. Quality of plies from straight, small-limbed and woods-run trees from butt and second logs, shown as a percentage of plies obtained

| | Straight, Small-Limbed | | Woods-Run | |
|---|---|---|---|---|
| Face Veneer | Prime Logs | Second Logs | Prime Logs | Second Logs |
| B | 47.2 | 2.8 | 39.7 | - |
| C | 21.5 | 19.1 | 33.3 | 32.7 |
| D | 16.4 | 52.0 | 6.4 | 49.0 |
| Core Veneer (includes strip and fishtail) | 14.9 | 26.1 | 20.6 | 18.3 |

The difference between the prime peeler logs and the second-quality peeler log is evident for both classes of tree. Although the straight, small-limbed trees yield more face B, the woods-run trees gave considerably more face C but less face D. The reasons for such differences are not clear.

Specialty tests are most valuable such as this one-year-old general combiner and disease diallel test of MacMillan Bloedel in Alabama. Information and plant material from the special tests are of great value to members of the Cooperative.

Based on dollar returns for yield, however, it is clear that small-limbed, straight trees, as found in a natural forest, will give considerably greater returns ($2.84/1000 lbs. trees green weight, or 12.65%) than woods-run material.

The value of these greater returns must be evaluated by each manufacturer. He is the only one who can really assign values for satisfying raw material costs, costs of manufacturing, selling expenses and allowable margins for profit and risk. From where we sit, we believe that the study will excite manufacturers of solid wood production who are involved in forest genetics. It can turn losses into profits or it can greatly increase the profits now being realized. In any event the 12.65% increase in product value/1000 lbs. of green tree weight causes imaginations to run a little wild.

As the lumber and plywood industry moves more in the southern pine region, questions are raised about qualities of the wood of young plantations. There is strong concern expressed about the adverse characteristics of wide-ringed wood without the knowledge that there is little difference in specific gravity (and therefore certain strength properties) between wide and narrow rings of wood of the same age. It is vital to remember the importance of age rather than ring width itself.

The fast-growing trees from seed orchards will be harvestable size at young ages and thus will have more juvenile wood and different wood qualities than older trees. (Our latest data show slightly higher specific gravities for the faster-growing families.) Solid wood products from young trees will have more juvenile wood and the wider rings will result in a different distribution of thin- and thick-walled cells within the stem. There is therefore justifiable concern as to the quality of solid wood products from plantations in the future made from young, wide-ringed trees with a high percentage of juvenile wood.

Dr. Ron Pearson of the Department of Wood and Paper Science has summarized a couple of studies of juvenile wood in Tables 24 and 25. It is evident that juvenile wood is weaker than mature wood at all levels in the tree's bole. Note the modulus of elasticity of the 10-year-old specimens compared to the mature wood. The weaker wood in young trees, even though of merchantable size, must be considered in the future to have strength properties similar to the juvenile wood at the center of larger trees from which studs are often sawed.

Table 24. Properties of juvenile and mature wood of loblolly pine from North Carolina 1/

| Property | Units | Type of Wood 2/ | Height Above Ground (ft.) 3 | 13 | 23 | 33 | 43 |
|---|---|---|---|---|---|---|---|
| Specific Gravity | g/cc | Juvenile | 0.47 | 0.43 | 0.41 | 0.41 | 0.41 |
| | | Mature | 0.53 | 0.48 | 0.45 | 0.43 | 0.44 |
| Modulus of Rupture (Corr. to 12% Moist. Cont.) | psi | Juvenile | 11000 | 12600 | 11800 | 11700 | 11800 |
| | | Mature | 14000 | 14900 | 13600 | 12900 | 13100 |
| Modulus of Elasticity (Corr. to 12% Moist. Cont.) | psi | Juvenile | 800 | 1670 | 1520 | 1490 | 1520 |
| | | Mature | 1500 | 2110 | 1860 | 1720 | 1760 |

1/ Specimens were cut from bolts 5 feet long selected from different heights above ground from 19 trees in Piedmont and Coastal regions of North Carolina. Specimens were 1" x 1" in cross-section, 16" long, tested in center-point loading over a span of 14".

2/ J = juvenile wood (Specimens were considered juvenile if their central growth ring was not more than the 10th ring from the pith.)

M = mature wood.

A major need is to develop trees that will grow well on marginal sites. Shown is a Virginia pine test planting of the N. C. Forest Service near Morganton, N. C. For the site index, this two-year-old planting has done well. Occasional Virginia pine in the tests on marginal sites has outstanding growth and form such as the one shown.

Even eroded Piedmont sites can grow outstanding trees, as shown by this 11-year-old loblolly test of Hoerner-Waldorf. A look at the site before planting would have left the impression that you couldn't even grow grass or weeds, let alone pine.

Table 25. Properties of 10-year-old thinnings of loblolly pine from Georgia[1/]

| Property | Units | Mean Values for Specimen Types[2/] Stud-sized Clear | Stud-sized Defective | Natural Rounds Clear | Natural Rounds Defective |
|---|---|---|---|---|---|
| Number of Specimens | | 259 | 228 | 154 | 242 |
| Specific Gravity | g/cc | 0.39 | 0.41 | 0.45 | 0.48 |
| Compression Parallel to Grain Maximum Crushing Strength Corrected to 12% M. C. | psi | 3690 | 2920 | 4600 | 4280 |
| Modulus of Elasticity at Test Corrected to 12% M. C. | psi | 669 | - | 1140 | - |

1/ The specimens came from 276 logs 6 feet long, cut between about 3 feet and 10 feet from ground level, from thinnings from the Heritability Study of International Paper Company and N. C. State Cooperative near Bainbridge, Georgia. The trees were planted in 1964 and cut in 1974. They came from parents randomly selected from the natural population of loblolly pine.

2(a)/ Small, clear specimens were 1" x 3/4" x 4" long compression specimens. Inner specimens were machined close to, but excluding, pith. Outer specimens were machined as close to bark as possible.

(b)/ Stud-sized specimens were 1-1/2" x 3-1/2" in cross-section with pith close to one wide face. Clear specimens were 8" long. Defective specimens were 10" long and contained one or more knots 3/4" diameter or larger.

(c)/ Natural round specimens were cut with ends square to length but without any other machining. Clear specimens were 10" long, defective specimens were 1/4" long and contained one or more knots 3/4" diameter or larger. Diameters ranged from 3.1" to 7.4".

Several years ago the Wood and Paper Science Department made an intensive study on wood qualities and pulp and paper properties, juvenile and mature, of a number of select trees with differing wood qualities from several members of the Cooperative. Results of the pulping study have been published but results of wood qualities of four selected trees (high-density, short fiber; high-density, long fiber; low-density, short fiber; low-density, long fiber) have not been reported before. Tracheid characteristics were subdivided into earlywood and latewood. Data showing wood qualities for trees having four types of wood and for the average of four young trees are shown in Table 26. All values are weighted averages for the merchantable portion of the tree.

Table 26. Wood properties of mature trees with differing wood qualities compared to young trees

| | High Density, Short Fiber | High Density, Long Fiber | Low Density, Short Fiber | Low Density, Long Fiber | Young Trees (4) |
|---|---|---|---|---|---|
| Average--Tree Age | 44 | 44 | 37 | 43 | 16 |
| DBH | 11.7 | 10.7 | 11.4 | 12.3 | 5.6 |
| # Bolts | 8.2 | 8.4 | 8.4 | 8.4 | 6.9 |
| Density (unextracted) | | | | | |
| Juvenile--Sp. Gr. | .44 | .44 | .38 | .41 | .42 |
| Lbs./cu.ft. | 27.5 | 27.5 | 23.7 | 25.6 | 26.2 |
| Mature--Sp. Gr. | .51 | .53 | .44 | .46 | - |
| Lbs./cu.ft. | 31.8 | 33.1 | 27.5 | 28.7 | - |
| Percent Moisture (O. D. Basis) | 104 | 101 | 125 | 111 | 134 |
| Tracheid Length (mm) | | | | | |
| Juvenile--Earlywood | 3.21 | 3.14 | 3.13 | 3.14 | 2.74 |
| Latewood | 3.42 | 3.40 | 3.37 | 3.57 | 2.61 |
| Mature--Earlywood | 4.1p | 4.40 | 3.95 | 4.46 | - |
| Latewood | 4.26 | 4.39 | 4.13 | 4.65 | - |
| Tracheid Dimensions | | | | | |
| Lumen Size (μ) | | | | | |
| Juvenile--Earlywood | 36.37 | 39.64 | 39.83 | 37.24 | - |
| Latewood | 17.67 | 15.86 | 19.14 | 18.47 | - |
| Mature--Earlywood | 51.30 | 42.79 | 44.91 | 45.16 | - |
| Latewood | 17.78 | 15.28 | 19.27 | 17.99 | |
| Cell Diameter (μ) | | | | | |
| Juvenile--Earlywood | 46.29 | 46.61 | 49.18 | 46.77 | - |
| Latewood | 39.42 | 38.94 | 41.68 | 39.81 | - |
| Mature--Earlywood | 51.43 | 53.02 | 54.67 | 54.87 | - |
| Latewood | 41.29 | 41.00 | 43.95 | 42.43 | - |
| Wall Thickness (μ) | | | | | |
| Juvenile--Earlywood | 4.96 | 4.98 | 4.68 | 4.77 | - |
| Latewood | 10.89 | 11.55 | 11.27 | 10.80 | - |
| Mature--Earlywood | 5.22 | 5.12 | 4.88 | 4.86 | - |
| Latewood | 11.76 | 12.86 | 12.34 | 12.22 | - |

Disaster strikes again! Near destruction of this progeny test of loblolly pine by hail on Westvaco's lands in Virginia set the test back a couple of years. Note the bark beaten off the side of the tree stem.

What can we grow on the very adverse sites? Westvaco has one possible solution under test. Shown are some loblolly-x-pitch pine hybrids being tested near Parkersburg, West Virginia. Certain combinations of parents have produced very promising hybrids, as shown by the growth of these three-year-old trees.

Points of interest are:

1. Moisture content of low-gravity trees was considerably higher than for high-gravity trees. The young trees had the highest moisture content.
2. Tracheid lengths for the low and high specific gravity trees were about the same; the young trees had decidedly shorter tracheids. Generally earlywood cells were shorter by 0.2 to 0.5 mm than those of the latewood, although there were two exceptions.
3. Earlywood cells are large, with large lumens and thin cell walls, compared to latewood tracheids.
4. There really was no difference in lumen size and cell diameter between the high and low density trees. Surprisingly, the wall thickness of latewood cells of high-density trees were no different from those of low-density trees, although the earlywood cell walls from low-density trees was less than that from the high-density trees. Obviously (though not shown in the table) the major cause of density difference between the two groups of trees was in the proportion of summerwood to springwood rather than in cell anatomy per se.

There is much interest in wood qualities as more plantations are harvested. Each member of the Cooperative received a mimeo of "Evaluation of the Effect of Rotation Age on Tree Quality." This report is a digest of an internal report of one company; they asked not to be identified but gave us permission to summarize results as follows:

1. Eighty-five percent of the wood in a 25-year-old plantation will meet density requirements by age 40.
2. It appears that the regular spacing in a plantation will produce more dense wood than from randomly spaced or poorly stocked naturally regenerated stands.

3. Thinning causes wider rings, but the lower two-thirds of the tree will meet density requirements if reasonable levels of thinning are used.
4. The width of annual rings is not a particularly limiting factor in producing solid wood from loblolly plantations.

Rayonier had two studies of open-pollinated slash pine progenies, one with 23 families, one with 22, that were thinned after eight years' growth in north Florida. Family differences were considerable, from .464 to .412 (avg. .434) on one test, .447 to .398 (avg. .420) on the other. The test included an analysis of 1124 trees with three fertilization levels but no significant differences were found by fertilizer treatment.

Wood From Tropical Pines

Because of our association with several overseas operations, we are occasionally asked to work on plantation-grown wood from tropical and subtropical areas. These are usually small, pilot-type studies, but results are indicative of what can be expected.

There have been several studies on wood qualities and products from fast growth plantations on pines in the Tropics and Subtropics. Generally wood is usable, giving acceptable yields and paper qualities despite the high proportion of juvenile wood resulting from fast growth and thus early harvest of the plantations. Some of the wood qualities have been reported in earlier annual reports and some new are reported below:

Wood Qualities of Fast Plantation Growth Pines in Tropics and Subtropics 1/

| Species | Age | General Location | Wood Sp. Gr. | Tracheid Length |
|---|---|---|---|---|
| *P. caribaea* | 15 | Brazil | 0.50 | 4.82 |
| *P. caribaea* | 5 | Brazil | 0.37 | 3.96 |

1/ Some values based on very small trees

Having the right species on the right site is of key importance. In the foreground is slash pine, in the background sand pine of the same age on deep sands on lands of Georgia Kraft in Georgia. We need to broaden the source base if all lands are to be fully productive.

One study was summarized with the statement that strength properties of young trees are considerably less than for older trees, sometimes below acceptability. All solid wood strength properties were related to wood specific gravity, as were yields and quality of paper. Younger trees thus produce poorer paper yields and paper with high mullen but low tear. Wood of P. caribaea had strength properties similar to but slightly less than young loblolly pine.

In one study, wood was obtained at roughly 3, 6.5, 10, 13 and 20 feet above ground for a few 15-year-old P. caribaea trees grown in a tropical area in South America. Additional data were available for 5-year-old trees; results are shown in Table 27.

Table 27. Wood specific gravity and wood density of several 15-year-old and 5-year-old P. caribaea grown in tropical areas, by height in tree

| Approx. Height Above Ground (ft.) | 15-yr.-old trees | | 5-yr.-old trees | |
|---|---|---|---|---|
| | Sp. Gr. | Lbs./Cu.Ft. | Sp. Gr. | Lbs./Cu.Ft. |
| 3.0 | .55 | 34.3 | .372 | 23.2 |
| 6.5 | .52 | 32.5 | .367 | 22.9 |
| 10.0 | .51 | 31.8 | - | - |
| 13.0 | .48 | 30.0 | - | - |
| 20.0 | .49 | 30.6 | - | - |

Trends found are similar to those for loblolly pine in the southeastern United States, with highest gravities at the base of the tree, lower up the tree bole. Young trees have lower gravities than do older ones, and the actual specific gravities of the 15- and 5-year-old trees are similar to loblolly pine. Variation among trees is large; for the 5-year-old trees, gravity values ranged from 0.28 to 0.45.

Wood of some of the tropical pines has very odd growth in the mature wood in which the thick band of summerwood has a whole series of thin-walled layers within it. This is caused by climate found in tropical areas.

Inheritance of Cellulose

Some years ago tests were made about the inheritance pattern of cellulose yields. Tree differences were found to be large (up to 7% per unit weight dry wood) and there was considerable interest in the potential of developing a high cellulose-yielding strain. Studies based on 4-year-old trees showed a strong inheritance but of a dominance type, indicating gains would not be possible using a standard selection program. The decision was made at that time to wait until trees were older to see if the pattern would be changed for older wood.

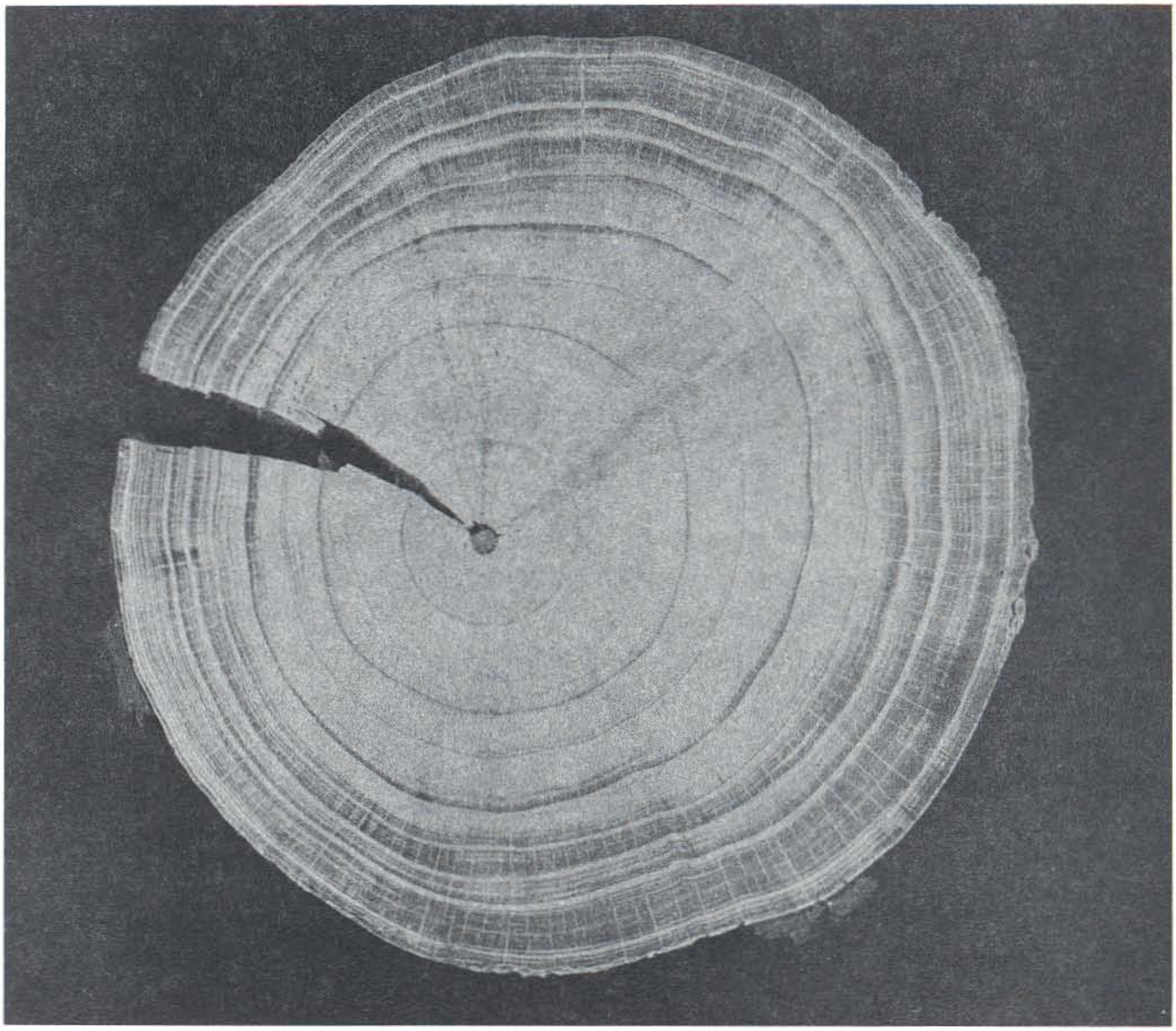
This past year an intensive study was made on 11-year-old loblolly pine of the Heritability Study with International Paper. Results were the same as for the 4-year-old trees, in that there was essentially no additive variance and high dominance variance. Large tree-to-tree differences were found, making family differences nonsignificant. Based on these results, the decision was made to terminate studies on the inheritance of cellulose.

## Miscellaneous--Pine

Orchard vs. Check

The proof of the program is in the performance of orchard stock compared to commercial stock. We have reported differences in earlier annual reports, but the obvious problem has always been that the orchard seed is from unrogued orchards that contain some inferior clones and the plantations are too young to obtain definitive results. Yet all point out gains possible from a seed orchard program.

Recent measurements of an operational planting by Union Camp in Montgomery County, Georgia made possible a comparison of seed orchard and commercial stock. Survival was essentially the same but height growth from orchard seed was 8% greater and diameter growth 17% greater than the commercial stock. Disease was 22% worse in the orchard stock, primarily because very disease-susceptible clones



Growth of pine in tropical climates is sometimes quite different from our southern pines. Note the clearly defined juvenile wood and the multiple springwood cells in the summerwood zone of the older wood of this cross-section of a P. caribaea tree.

like 10-8 had not yet been rogued. Although trees were too small for meaningful volume calculations, a comparison showed a volume superiority of 18% for the seed orchard material.

Pollen Storage

Difficulties experienced by cooperators in successful pollen storage, plus the need for a central pollen bank at North Carolina State for the future breeding program, led to a series of investigations on pollen extraction and storage methods. In the fall of 1972 the Cooperative staff constructed a pollen extractory in a room where the pollen could be extracted and dried under controlled temperature-humidity conditions. An apparatus for flame-sealing pollen under vacuum was also constructed, and studies to compare the vacuum storage method with conventional methods were initiated in the spring of 1973. Conventional methods included pollen refrigerated in (1) tightly-capped bottles, (2) cotton-stoppered bottles, and (3) cotton-stoppered bottles inside a desiccator. Conclusions of the investigations were:

1. The vacuum method of pollen storage is an effective method and yields higher viability than the conventional methods.
2. Conventional methods may be sufficient for short-term storage (two to three years).
3. The most critical factor in pollen storage appears less dependent on the method used than on the moisture content at the time pollen is put into storage. A moisture content of 8 to 10% is best for storing pollen. The pollen extractor constructed is very effective in lowering the moisture content to this level.

## Membership of the Pine Cooperative

| Organization | Working Units and States |
| --- | --- |
| American Can Company (Southern Woodlands Division) | Ala., Miss. |
| Brunswick Pulp Land Company | S. C., Ga., Fla. |
| Catawba Timber Company (Bowaters Carolina) | S. C., N. C., Va., Ga. |
| Champion International | Alabama Div.--Ala., Tenn.<br>Carolina Div.--S. C., N. C., Ga. |
| Chesapeake Corporation of Virginia | Va., Md., Del., N. C. |
| Container Corporation of America | Ala. |
| Continental Forest Industries | Savannah Div.--S. C., Ga.<br>Hopewell Div.--N. C. Va. |
| Federal Paper Board Co., Inc. | N. C., S. C. |
| Georgia Kraft Company | Ga., Ala. |
| Georgia-Pacific Corporation | Va., N. C., S. C., Ga., Fla. |
| Great Southern Paper Company | Ga., Ala., Fla. |
| Hammermill Paper Company | Ala. |
| Hiwassee Land Company (Bowaters Southern) | Tenn., Ga., Ala., Miss., N. C. |
| Hoerner-Waldorf Corporation (Halifax Timber Division) | N. C., Va. |
| International Paper Company | S. C., N. C., Ga. |
| Kimberly-Clark Corporation (Coosa River Division) | Ala. |
| MacMillan-Bloedel Corporation | Ala., Miss. |
| Masonite Corporation | Miss. |
| North Carolina Forest Service | N. C. |
| Rayonier Inc. | Fla., Ga., S. C. |
| South Carolina State Commission of Forestry | S. C. |
| St. Regis Paper Company | Ala., Miss., W. Fla. |
| Tennessee River Pulp and Paper Company | Tenn., Ala., Miss. |
| Union Camp Corporation | Savannah Div.--Ga., S. C., Ala.<br>Franklin Div.--N. C., Va. |
| Virginia Division of Forestry | Va. |
| Westvaco Corporation | South--S. C.<br>North--Va., W. Va., Ohio, Tenn., Ky., Miss. |
| Weyerhaeuser Company | N. C. Div.--N. C., Va.<br>Miss.-Ala. Div.--Miss., Ala. |

## GRADUATE STUDENTS

It has become increasingly frustrating to select graduate students for the Cooperative Programs. The frustration is that we have to be extremely selective from the list of well-qualified applicants because of a shortage of assistantship funds. It is heart-rending to reject a student with a near-perfect grade point average and excellent references because of the lack of funds, but we have no alternative.

In 1976 we gave six assistantships or fellowships out of more than twenty applicants; in 1977 money was available to give only two assistantships from over 25 students who inquired. This was the best "crop" of potential students we have had in 25 years. Monies used are from general Cooperative funds as well as those from the School of Forest Resources, N. C. Agricultural Experiment Station, the Gunnar Nicholson Fellowship, the Weyerhaeuser and Union Camp Fellowships, from International Paper through a grant for tissue culture being done by Dr. Ralph Mott, and other. We have attempted to get additional funds from granting agencies but have not been successful in recent years. The usual rejection statement is, "You have industry monies" or "You should be funded by the U. S. Forest Service.

Assistantships are given only to U. S. students. We are again obtaining a good cadre of foreign students, a fact we feel is necessary for a balanced graduate program. On the next page (Table 40) are listed the students who are in residence and those who have completed their work during the past year.

Table 40. Students associated with the Pine and Hardwood Cooperatives

Work recently completed:

| Name | Field | Status |
| --- | --- | --- |
| Gallegos, Carl | Siting of seed orchards | Ph. D.--International Paper Company |
| Gregory, Jim | Subsoiling seed orchards | Ph. D.--V. P. I. |
| Jaramillo, Carlos | Special Student | Colombia, S. A. |
| Overton, Ron | Flowering of sycamore | Ph. D.--State of Indiana |
| Owino, Fred | Genetics of wide crosses of loblolly pine | Ph. D.--Kenya |
| Smith, Don | Economics of spacing and site preparation | Ph. S.--Potlatch Corp. |
| Veal, Mick | Effect of fusiform on wood properties | Ph. D.--Weyerhaeuser |
| Weir, Bob | Breeding for fume resistance | Ph. D.--Director, Tree Improvement Program |
| White, Tim | Longleaf conelet abortion | M. S.--Oregon |

| Ph. D.--In residence: | | Origin/Status |
| --- | --- | --- |
| Braham, Richard | Field morphology of hardwood sprouts | Michigan |
| Gomide, Jose | Wood properties of Eucalyptus | Brazil |
| Jett, J. B. | Flowering of pine | Assoc. Director, Tree Improvement Program |
| Kang, Hyun-Chung | Quantitative genetics | Syracuse |
| Lambeth, Clem | Progeny productivity | Weyerhaeuser employee |
| Liegel, Leon | Fertility requirements of tropical pines | Puerto Rico (USFS) |
| Rose, Robert | Sweetgum plantations | Union Camp Fellowship |
| Ståhl, Per | Competition in loblolly pine | Nicholson Fellowship |
| Talbert, John | G x E interaction of loblolly pine | Weyerhaeuser Fellowship |
| Wearstler, Ken | Competition in loblolly pine | Weyerhaeuser employee |
| Weber, Joseph | Variation in Fraser fir | Louisiana |
| Pousugg, Reungchai | (Undecided) | Thailand |

| M. S.--In residence: | | |
| --- | --- | --- |
| Butler, Emily | Cold-hardiness of Eucalyptus | Tennessee |
| Cretcher, Gary | Variation in willow oak | Ohio |
| Gonçalves, Paulo | Management of black alder | Brazil |
| Hunter, Serena | Isozyme analysis of loblolly | Tennessee |
| Kelly, Charles | Tissue culture analysis | New Jersey |
| Leach, Gregory | Tissue culture analysis | Syracuse |
| Lewis, Clifford | Natural regeneration, hardwoods | Forest consultant |
| McCall, Early | Abortion of longleaf pine conelets | North Carolina |
| Paschke, Jeff | Timing of progeny measurements | Indiana |
| Schoenhofen, Leo | Economics of hardwoods | Union Camp employee |

## PUBLICATIONS

## BY MEMBERS OF THE COOPERATIVE

Gallegos, C. M. 1976. Criteria for seed orchard site selection in loblolly pine (Pinus taeda L.). Ph. D. Thesis. N. C. State Univ., Raleigh. 81 pp.

Gibson, G. E. and E. C. Sossaman. 1976. Fifteen-year results on a sweetgum spacing study. 6 pp. (In press)

Kellison, R. C. 1976. Progress of the N. C. State University-Industry Cooperative Tree Improvement Program. Forest Farmer 36(3):11-14.

Kellison, R. C. 1976. The silviculture and management of the southern United States coniferous forests--The way Americans meet the growing challenge. Paper given at Canadian Inst. of Forestry and the Ontario Professional Foresters' Assn., Thunder Bay, Ont. 11 pp. Forest Chronicle 52(6):1-4.

Kellison, R. C., R. D. Heeren and S. Jones. 1976. Species selection as related to soils in the Atlantic Coastal Plain. Paper presented to the Sixth Southern Forest Soils Workshop, Charleston, S. C. Oct. 20-21. 7 pp.

Kellison, R. C. 1977. Silvicultural impacts on production forestry in the South. Paper presented at 56th Ann. Meet., SAF, Appalachian Sec., Richmond, Va. Jan. 26-28. 10 pp. (In press)

Kellison, R. C. and R. J. Dinus. 1977. Recent advances in genetic improvement of Pinus taeda and P. elliottii in the southern United States. Third World Consultation on Forest Tree Breeding, Canberra, Australia. 8 pp. (In press)

Mallonee, E. H., Jr. 1975. Effects of thinning and seasonal time of nitrogen fertilization on the growth of pole-sized loblolly pine (Pinus taeda L.). Ph. D. Thesis. Dept. of Forestry, N. C. State Univ., Raleigh. 110 pp.

Mott, R. L., R. H. Smeltzer, A. Mehra-Palta and B. J. Zobel. 1977. Production of forest trees by tissue culture. Preprint of paper to be presented by R. L. Mott at 1977 TAPPI Ann. Meet., Atlanta, Ga. Feb., 1977. 15 pp.

Sombun, K. 1975. Germination tests of loblolly pine (Pinus taeda) seeds treated with different fertilization and insecticides. M. S. Thesis. School of Forest Resources, N. C. State Univ., Raleigh.

Squillace, A. E., D. G. Nikles and L. C. Saylor. 1977. Monoterpene composition in cortical oleoresin of Pinus caribaea and relation to P. elliottii of Florida. Third World Consultation on Forest Tree Breeding, Canberra, Aust. Session 2: Advances in Species and Provenance Selection. 19 pp.

White, T. L., H. G. Harris, Jr. and R. C. Kellison. 1976. Conelet abortion in longleaf pine. 16 pp. (In press)

Woessner, R. A., C. B. Davey, B. E. Crabtree and J. D. Gregory. 1975. Nutrient content of the aboveground tissue of 12-week-old loblolly pine intraprovenance and interprovenance crosses. Can. Jour. For. Res. 5(4):592-598.

Zobel, B. J. 1975. Our changing wood resource--its effect on the pulp industry. Applied Polymer Symp. No. 28, pp. 47-54.

Zobel, B. 1975. Using the juvenile wood concept in the southern pines. Southern Pulp and Paper Manufacturer. Sept. pp. 14-16.

Zobel, B. 1976. Wood properties as affected by changes in the wood supply of southern pines. Tappi 59(4):126-128. April Issue.

Zobel, B. 1976. Production of quality hardwoods by the large forest industries. Fourth Ann. Hdwd. Symp., Hardwood Research Council, Cashiers, N. C. April 29-30. 8 pp.

Zobel, B. J. and R. Blair. 1976. Wood and pulp properties of juvenile and topwood of southern pines. Applied Polymer Symp. No. 28, pp. 421-433.

Zobel, B. and M. Zoerb. 1976. Reducing fusiform rust in plantations through control of the seed source. Given at Symp. on Fusiform Rust of Southern Pine, Gainesville, Fla. Dec. 7-8. 11 pp. (In press)

Zobel, B. J. 1977. Will timber resources of the southern United States meet the demands. Paper given at Ann. Meet., TAPPI. February. 4 pp. (In press)

Zobel, B. 1977. Increasing pine timber production from southern forest lands. Southern Journal of Applied Forestry. (In press)
(Rev. of "Increasing Timber Production from Forest Lands," Burgess-Lane Lectureship, Univ. of British Columbia, Vancouver, B. C. Nov. 19, 1975. 26 pp.)

The species is Homo sapiens. Note the dense pine forest where the species is commonly found. It is thought that the expression of the foremost subject is the result of genetic stress but that supposition could not be verified.